# Association of the Built Environment With Physical Activity and Obesity in Older Persons

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*Objective.* We examined whether older persons who live in areas that are conducive to walking are more active or less obese than those living in areas where walking is more difficult.

*Methods.* We used data from the Adult Changes in Thought cohort study for a cross-sectional analysis of 936 participants aged 65 to 97 years. The Walkable and Bikable Communities Project previously formulated a walkability score to predict the probability of walking in King County, Washington. Data from the cohort study were linked to the walkability score at the participant level using a geographic information system. Analyses tested for associations between walkability score and activity and body mass index.

*Results.* Higher walkability scores were associated with significantly more walking for exercise across buffers (circular zones around each respondent's home) of varying radii (for men, odds ratio [OR] = 5.86; 95% confidence interval [CI] = 1.01, 34.17 to OR = 9.14; CI = 1.23, 68.11; for women, OR = 1.63; CI = 0.94, 2.83 to OR = 1.77; CI = 1.03, 3.04). A trend toward lower body mass index in men living in more walkable neighborhoods did not reach statistical significance.

*Conclusions.* Findings suggest that neighborhood characteristics are associated with the frequency of walking for physical activity in older people. Whether frequency of walking reduces obesity prevalence is less clear. (*Am J Public Health.* 2007;97:486–492. doi:10.2105/AJPH.2006.085837)

In the United States, obesity has been called an epidemic: an increasing proportion of Americans are overweight or obese.[1,2] Numerous studies have highlighted the large proportion of overweight and obese adults, and the number of older adults who are overweight or obese continues to rise.[3,4] Obesity has been associated with many health problems, including cardiovascular disease, diabetes, some cancers, depression, and arthritis.[2,5–10] Physical activity is believed to be an important determinant of health and body weight. Most Americans do not regularly engage in physical activity,[11] and efforts are being made nationally to increase the activity level of the population to prevent comorbid disease.

Older people are at increased risk of decline in functional independence as they age. Of community-dwelling adults aged 75 years or older, 10% lose independence each year, as measured by activities of daily living.[12] A decline in independence is associated with higher rates of hospitalization and mortality.[13] In addition to its inverse association with obesity, exercise is associated with a slowing in functional decline[14] and dementia[15] and may help some older persons maintain functional independence. Older adults may choose walking as a form of physical activity, both for recreation and as a means of transport for completing tasks of daily living.

An older person's activity level may be influenced by the built environment, which is defined by the Centers for Disease Control and Prevention as human-formed, developed, or structured areas.[16] Neighborhood aesthetics, convenience to destinations, availability of paths and sidewalks, and other environmental attributes are believed to influence the walkability of a neighborhood.[17] As people age they may spend a greater amount of time around their homes and have the opportunity to walk for exercise or for transportation; thus the study of the built environment in relation to activity and obesity is important. Some have called for gender-specific analysis of physical activity, citing differences in the perception of environment, convenience to destinations, and automobile use.[18,19] Indeed, older women appear to take fewer trips per day than do older men, indicating that the tendency to travel by any means, including walking, varies by gender.[20]

Little is known about the association between the built environment and activity and obesity in older men and women. Recently, new measurement tools have made study of the relation between obesity, physical activity, and the built environment possible.[17,21,22] Our study explored whether more walkable neighborhoods are associated with more activity and less obesity in older men and women.

## METHODS

### Participants

Group Health Cooperative is a consumer-governed, staff-model health maintenance organization in Washington State with more than 500 000 members. Study participants were drawn from the Adult Changes in Thought (ACT) study, a prospective, longitudinal cohort study of older patients aimed at detecting the onset of dementia. The ACT study began in 1994 and initially enrolled approximately 2500 randomly selected, cognitively intact participants aged 65 years or older who were Group Health patients in clinics serving western King County. Details of the sample are available elsewhere.[15,23] Approximately 2000 participants were used in our analysis, corresponding to the sample size available at the 2002 assessment. The included participants were cognitively intact as defined by a Cognitive Abilities Screening Instrument score of 86 or higher,[24] which corresponded to a Mini-Mental Status Examination score of 25 to 26 or higher. All participants resided in King County, Washington, where the geographic model used in this analysis could be applied. Data were extracted from ACT study assessments occurring between January 1, 2001, and December 31, 2003, because this period most closely corresponded to the period in which geographic data were collected. After these selection criteria were applied, 1967 participants were eligible.

During in-person visits conducted every 2 years with ACT participants, information was collected on activity and obesity. Measured height and weight were used to calculate body mass index (BMI; weight in kilograms divided by height in meters squared), a common measure of overweight and obesity. A self-report of physical activity was collected at each biennial visit. A written survey queried participants on the number of times per week they participated in various physical activities for exercise that lasted at least 15 minutes per session. The survey is described in more detail in a recently published study of the relation between physical activity and dementia.[15] Our analysis used the measure of walking for exercise from the questionnaire, with the question, "During the last year, how many days per week did you walk for exercise for at least 15 minutes at a time?" Other measures of activity, such as swimming, biking, and weight lifting, were not used in our analysis, because we felt they would not be significantly influenced by neighborhood walkability.

The ACT study also provided several covariates that may confound the relation between neighborhood walkability and walking activity and obesity, including age, gender, education level, income, living alone, tobacco use, and self-reported information on arthritis. Depression was measured using the Center for Epidemiological Studies Depression Scale, a 20-item questionnaire validated in an older population.[25,26] Group Health Cooperative prescription claims records were used to assess chronic disease burden. The Rx Risk score, derived from pharmaceutical use as an indicator of disease burden, was calculated for each respondent.[27]

## Geographic Data

An earlier study, the Walkable and Bikable Communities (WBC) project, provided scores for neighborhood walkability. The WBC project, based in King County, Wash, and unrelated to the ACT study, identified components of the built environment that contributed to increased walking and biking. It used a behavioral model of environment and the travel-based principles of origin, destination, route, and area to structure the environmental determinants of physical activity.[28] Information from a telephone survey of 608 randomly selected adult respondents in an 88-square-mile region of urbanized King County was combined with objective tax parcel–level geographic data from publicly available sources.[29] The spatial sample frame consisted of medium- and high-density residential areas of King County, with services (shops, schools, offices, etc.) close to homes. Details of the spatial sample frame construction are described elsewhere.[30] The 27-minute survey included questions from the Behavioral Risk Factor Surveillance System, International Physical Activity Questionnaire–Long, and National Health Interview Survey, as well as additional questions described by Brownson et al.[31]

The WBC study then captured data on approximately 200 directly observable neighborhood attributes with 900 related measures within 1-km and 3-km circular zones (buffers) around each respondent's home and measured distance to destinations up to 3 km from a respondent's home. Objective measures of the built environment included land-use characteristics from the parcel-level assessor's files, park information, streets and foot and bike trails, land slope, vehicular traffic, and public transit data. The WBC study estimated, by multinomial logistic regression, the likelihood of walking more than 150 minutes per week, corresponding to the Centers for Disease Control and Prevention recommendations for sufficient physical activity,[32] versus not walking at all or walking moderately (<150 minutes per week).

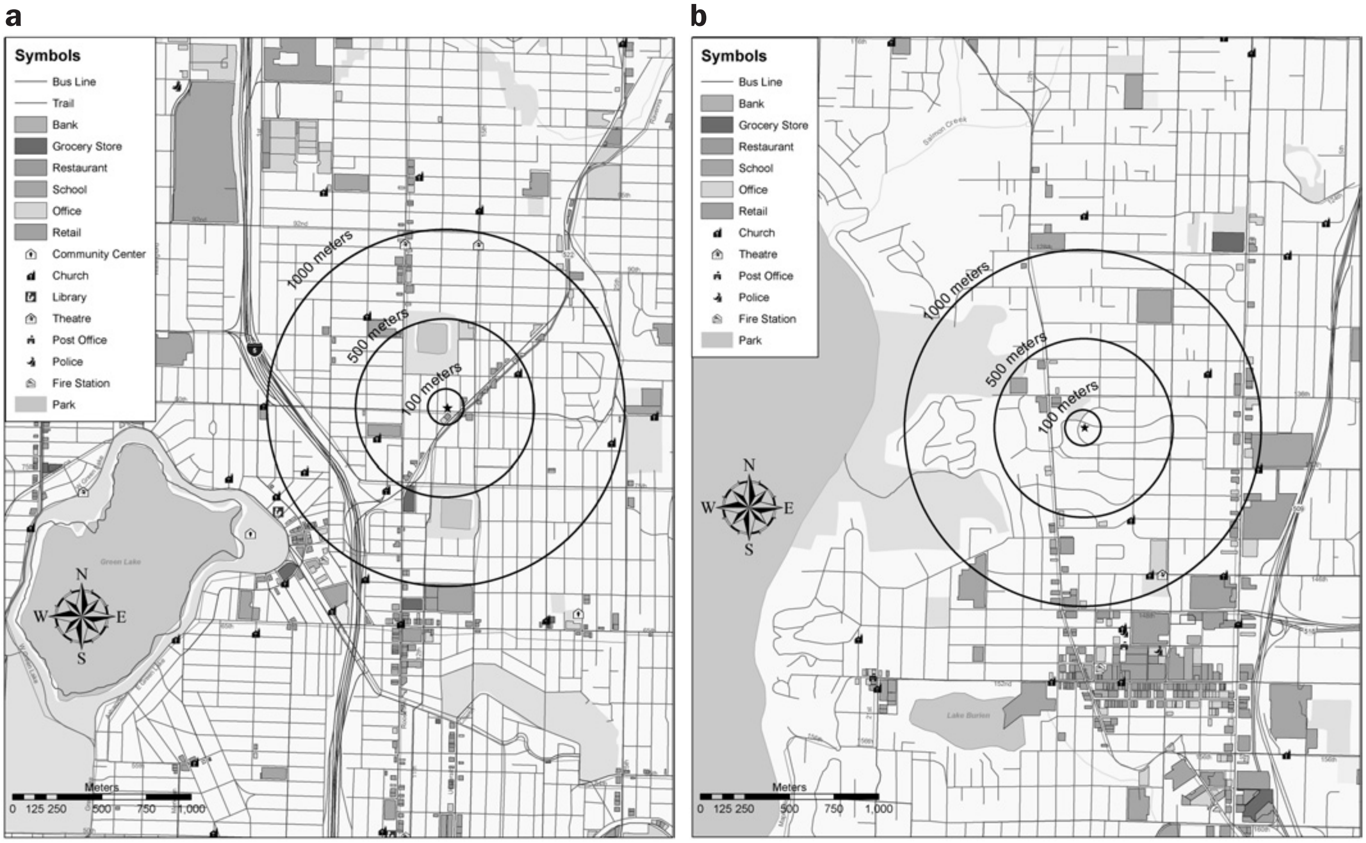
We used variables from the survey in a 2-step modeling process to create a base model. Those survey variables found statistically significant or considered theoretically important were kept in the final models. The variables retained from the first step plus 200 environmental variables were used for the second step. Two final models were created: 1 for straight-line distances from the respondents' homes (i.e., as the crow flies) and 1 for network distances along existing transportation routes (i.e., traveling along the streets). Of the 200 objective environmental variables assessed, 8 were found to have a significant effect on walkability in the straight-line model and were used to compute the walkability scores (Table 1). Details of the methods used to derive the walkability index are described elsewhere.[21,22,34]

Finally, we calculated walkability scores for the entire surface of the spatial sample frame. This surface model was based on the final straight-line model. We controlled for survey variables and calculated walkability scores for the significant environmental features of the

**TABLE 1—Predictors of Walkability in the Built Environment: Adult Changes in Thought Study, King County, Washington, 2001–2003**

| Environmental Characteristic (Threshold Value)[a] | Odds Ratio[b] (95% Confidence Interval) |
|---|---|
| Shorter distance to closest grocery store (<440 m) | 2.26 (1.12, 4.56)* |
| More dwelling units per acre of the parcel where the residence is located (>21.7) | 1.96 (1.15, 3.35)* |
| More grocery store, restaurant, or retail clusters in 1-km buffer (>1.8) | 1.70 (1.11, 2.60)* |
| Fewer educational parcels in 1-km buffer (<5.1) | 1.55 (0.94, 2.58)** |
| Fewer grocery stores or markets within 1-km buffer (<3.7) | 1.50 (1.02, 2.20)* |
| Smaller size of closest office complex (<36 659 sq m) | 1.28 (1.08, 1.53)* |
| Longer distance to closest office/mixed-use complex (>544 m) | 1.27 (1.04, 1.56)* |
| Smaller size of block where residence is located (<23876 sq m) | 1.19 (0.99, 1.43)** |

*Source.* Adapted from Moudon et al.[33] In press.
*Note.* Pseudo-$R^2$ of full model = 0.34 (using the Cox and Snell test).
[a]Threshold values of characteristics for active walking environments are derived from mean values for subjects walking > 150 min/wk vs not walking.
[b]Odds of walking > 150 min/wk vs not walking, using a straight-line measurement
*$P$ < .05; **$P$ < .1.




*Note.* The more walkable neighborhood has a denser street network and better connectivity of streets than does the less walkable neighborhood. Although the less walkable neighborhood appears to have more retail destinations, it is beyond the distance a respondent would be expected to walk.

**FIGURE 1—Example analysis of participants in more walkable (a) and less walkable (b) neighborhoods.**

respondents' home locations and for additional points on a 1-km grid within the spatial frame. To obtain values for the continuous surface, we used a radial basis function to interpolate the values of areas between the points, thereby creating a smoothed-surface model.

We used a geographic information system (ArcView 9.0, ESRI, Redlands, Calif) to geocode each ACT participant's address to the associated tax assessor's parcel. If the address could not be geocoded with parcel data, King County street file data were used to geocode the address. Circular buffers of 100, 500, and 1000 m were created around each point (Figure 1). Buffer sizes were representative of distances usually traveled on foot, with smaller buffers representing distances that may be more commonly traveled by older people. The 1000-m buffer corresponded to other analyses of behavior and the built environment.[17,22] The model computed walkability scores on a scale of 0 to 100 for each subject within the area of each buffer. These walkability data were then merged with the respondent data from ACT for analysis.

### Statistical Analysis

Participants were, a priori, stratified into 4 gender-specific groups: those who lived at the same address 2 years prior to their clinical assessment (men and women) and those who moved to a new address in the 2 years since their last assessment (men and women). Only participants living in the same home for at least 2 years were included in the analysis of BMI (n=740), because we hypothesized that the effect of the built environment on a change in BMI might take longer than 2 years to detect. All 4 groups were included in the analysis of self-reported walking (n=936), because adaptation of this behavior would be expected in less than 2 years. We chose to stratify participants on gender because previous research showed different patterns of walking for activity between men and women.[18–20,35]

We used *t* tests and $\chi^2$ analyses to analyze differences between men and women and between those living at the same address and a different address 2 years prior to the study. Multiple logistic regression was used to determine the associations between neighborhood walkability and self-reported walking and BMI. Regression analyses controlled for Center for Epidemiological Studies Depression Scale score, income, education, tobacco use, living alone, self-report of arthritis, age, and RxRisk as a measure of chronic disease burden. Statistical analyses were performed with Stata version 9 (Stata Corp, College Station, Tex).

**TABLE 2—Participant Characteristics: Adult Changes in Thought Study, King County, Washington, 2001–2003**

| | Total (N = 936) | Women (n = 601; 64.2%) | Men, (n = 335; 35.8%) |
|---|---|---|---|
| Age, y,* mean (SD) | 78.5 (6.1) | 78.9 (6.1) | 77.8 (6.0) |
| 65–74 | 27.2 | 24.6 | 31.9 |
| 75–84 | 54.4 | 54.9 | 53.4 |
| 85–94 | 18.1 | 20.0 | 14.6 |
| ≥95 | 0.3 | 0.5 | 0 |
| CES-D score,** mean (SD) | 5.8 (6.5) | 6.4 (6.9) | 4.7 (5.4) |
| RxRisk, $,** mean (SD) | 4142.1 (2307.9) | 3924.3 (1422.7) | 4532.6 (2223.3) |
| Income > $30 000,** % | 49.3 | 37.6 | 69.1 |
| Education, > 12 y, % | 69.7 | 68.8 | 71.2 |
| Lives alone,** % | 45.5 | 55.1 | 28.3 |
| Uses tobacco,** % | 10.4 | 4.7 | 20.3 |
| Suffers from arthritis, % | 3.7 | 4.1 | 3.0 |
| BMI, kg/m$^2$, mean (SD) | 27.0 (5.0) | 27.0 (5.7) | 27.1 (3.6) |
| Overweight or obese,** % | 63.2 | 59.3 | 70.3 |
| Walks any amount for exercise, % | 48.4 | 46.1 | 50.9 |
| Living in same home at least 2 years,[a] % | 79.1 | 77.9 | 81.2 |

*Note*. CES-D = Center for Epidemiological Studies Depression Scale; RxRisk = chronic disease burden: BMI = body mass index.
[a]Persons living at the same address for at least 2 years were younger ($P = .007$) and had higher RxRisk scores ($P < .001$) than did those living at a different address 2 years prior to the study.
*$P = .01$, comparing men and women; **$P < .001$, comparing men and women.

## RESULTS

Of the 1967 potentially eligible respondents in the data set, 1770 participants were successfully geocoded with tax parcel data or King County street file data (90%). Of those participants, 936 (53%) were living within the spatial sample frame of the WBC surface model. Only the latter were studied. The remainder of the participants either lived outside the spatial sample frame (n = 637) or were unsuccessfully geocoded because of missing or incorrect address information (n = 197).

Participants ranged in age from 65 to 97 years, with a median age of 78 years. BMI ranged from 14.2 to 65.4, with a median BMI of 26.3. As a group, approximately 63% of participants had BMIs in the overweight (25.0–29.9 kg/m$^2$) or obese (30.0 kg/m$^2$ or more) range, and approximately half reported no walking for exercise (Table 2). About 1 in 5 participants had moved to a new home in the 2 years prior to the assessment. A higher proportion of men than women reported incomes of $30 000 or more and tobacco use. Women were older and had a lower RxRisk score, indicating less chronic disease burden, but had higher Center for Epidemiological Studies Depression Scale scores and more often lived alone.

A statistically significant association was detected between neighborhood walkability and any self-reported weekly walking sessions in men and women living at a different address in the 2 years prior to assessment, regardless of buffer size, and in women but not in men living at the same address for 2 years or more. Odds ratios of any self-reported walking for the difference between the 75th percentile and 25th percentile neighborhood walkability scores (interquartile range) are reported in Table 3.

There was no significant association between higher neighborhood walkability and the proportion of participants in the overweight or obese range, although in most comparisons the association was in the hypothesized direction. Participants living in a different home 2 years prior to assessment did not exhibit an association between BMI and neighborhood walkability (data not shown).

## DISCUSSION

Our study suggests that the built environment, as described by a neighborhood walkability score, is associated with increased walking for exercise in men and women. Models of walkability that take into account types of and distance to destinations and residential density may be a useful predictor of physical activity in older adults. The association was seen at several buffer sizes representing potential distances traveled by older people. If this finding is confirmed by other studies, the association between neighborhood walkability and physical activity may be adapted for use by community planners, health care providers, and older people. Planners could choose to design neighborhoods that are more walkable, with both transportation and recreation destinations. Health care providers could tailor specific activity recommendations, taking into account where the patient lives. Older adults may use information on neighborhood walkability as they select a new residence or community after retirement.

We found no statistically significant association between the built environment and obesity in those who have remained in the same home for 2 years or more. It is possible that a hypothesized lag time of 2 years was insufficient to detect an association. Other researchers have used several different metrics to find varying strengths of association between the built environment and weight,[36–41] indicating that additional study of this relation is warranted.

Other studies have found similar associations between physical activity and walkability, isolating net residential density, street connectivity, and land-use mix as significant measures.[42–44] The WBC walkability model used in this study encompasses these variables and provides precise measurements as well as additional information about the type of land-use mix that optimizes walking. The model showed that proximity to grocery stores, smaller block sizes, and higher residential density at the level of the respondent's parcel was associated with more walking within the neighborhood. Clusters of destinations, such as grocery stores, restaurants, and retail, also increased the odds of walking sufficiently to meet Centers for Disease Control

**TABLE 3—Odds Ratios (ORs; With 95% Confidence Intervals [CIs]) for Association of Neighborhood Walkability Score (Interquartile Range) With Self-Reported Walking for Exercise (Any vs None) and Body Mass Index (BMI): Adult Changes in Thought Study, King County, Washington, 2001–2003**

| Outcome | Buffer Radius, m | Walkability Score (0–100), 75th percentile | Walkability Score (0–100), 25th percentile | Adjusted OR (95% CI) | P |
|---|---|---|---|---|---|
| **Self-Reported Walking for Exercise** | | | | | |
| Changed address in past 2 y | | | | | |
| Men (n = 63) | 100 | 47.90 | 30.65 | 9.14 (1.23, 68.11) | 0.031 |
| | 500 | 47.71 | 31.65 | 6.64 (1.05, 42.07) | 0.045 |
| | 1000 | 46.17 | 31.58 | 5.86 (1.01, 34.17) | 0.049 |
| Women (n = 133) | 100 | 47.90 | 30.65 | 1.63 (0.94, 2.83) | 0.083 |
| | 500 | 47.71 | 31.65 | 1.73 (0.99, 3.00) | 0.052 |
| | 1000 | 46.17 | 31.58 | 1.77 (1.03, 3.04) | 0.040 |
| Living at same address ≥ 2 y | | | | | |
| Men (n = 272) | 100 | 47.90 | 30.65 | 0.88 (0.62, 1.26) | 0.494 |
| | 500 | 47.71 | 31.65 | 0.87 (0.61, 1.25) | 0.464 |
| | 1000 | 46.17 | 31.58 | 0.92 (0.62, 1.36) | 0.680 |
| Women (n = 468) | 100 | 47.90 | 30.65 | 1.33 (1.00, 1.77) | 0.050 |
| | 500 | 47.71 | 31.65 | 1.34 (0.99, 1.80) | 0.055 |
| | 1000 | 46.17 | 31.58 | 1.36 (0.99, 1.87) | 0.061 |
| **BMI[a]** | | | | | |
| Living at same address ≥ 2 y | | | | | |
| Men (n = 272) | 100 | 47.90 | 30.65 | 0.78 (0.54, 1.16) | 0.225 |
| | 500 | 47.71 | 31.65 | 0.80 (0.53, 1.19) | 0.270 |
| | 1000 | 46.17 | 31.58 | 0.75 (0.48, 1.17) | 0.208 |
| Women (n = 468) | 100 | 47.90 | 30.65 | 0.99 (0.74, 1.32) | 0.928 |
| | 500 | 47.71 | 31.65 | 1.02 (0.75, 1.38) | 0.902 |
| | 1000 | 46.17 | 31.58 | 0.93 (0.67, 1.28) | 0.646 |

*Note*. CES-D = Center for Epidemiological Studies Depression Scale; RxRisk = chronic disease burden. Analyses were adjusted for CES-D score, income, education, arthritis, age, RxRisk score, living alone, and tobacco use.
[a]Data presented only for persons living at same address for 2 years or more, because we hypothesized that the effect of the built environment on a change in BMI might take longer than 2 years to detect.

and Prevention guidelines.[23] Too high a number of grocery stores and schools as destinations, and overly large concentrations of offices, however, could negatively affect the walkability of a neighborhood; the ideal walkable community would have a balance of retail and residential spaces, with small block sizes and small amounts of land in office or educational uses. This description mirrors the design of many older urban and suburban neighborhoods, built before the shift to substantial reliance on automobiles as a means of transportation.

One study to date has assessed the relationship between neighborhood attributes and physical activity in older women, demonstrating an association with proximity to golf courses and post offices.[45] Although the study used a different metric for assessing neighborhood walkability and did not look at the association of neighborhood walkability with obesity, it also found that walking occurs more often in neighborhoods with a variety of destinations. Another study of older women found that walking to services occurred more often in traditional urban neighborhoods than in newer suburban neighborhoods.[46]

Creating more walkable neighborhoods may provide other benefits. A study in Ireland demonstrated that pedestrian-oriented neighborhoods are more socially engaging.[47] This may be particularly important to older persons because they are often at risk of becoming socially isolated. Making safe neighborhoods may help prevent injuries. Older people are at relatively high risk for fatalities and injuries from collisions with motor vehicles at crosswalks, which may decrease their desire to walk to a destination or walk for recreation.[48] Such a decrease in physical activity negatively affects functional independence.[49] Redesigning neighborhoods or fixing specific barriers to walking, such as damaged sidewalks, to improve pedestrian safety might increase walking.

### Limitations

This study had several limitations. The analyses used cross-sectional data on the built environment and participants, making the establishment of a causal link between obesity and walkability difficult. In contrast to the idea of the neighborhood modifying the behavior of the resident, more-active older adults may choose to live in more-walkable neighborhoods and less-active adults in less-walkable neighborhoods. This may be especially true for retirees and empty nesters with time to participate in new activities. Other, unmeasured confounding variables may also influence obesity or activity. Although the study adjusted for age, education, income, depression, living alone, chronic disease burden, arthritis, and tobacco use, other measures, such as perception of safety, seasonality, and social support, could not be addressed with available data. Also, the possible effect of spatial correlation on the sample was not measured because of the confidentiality measures in place to protect subject identifiable data.

The decision to stratify by gender and length of time a person lived in his or her home potentially created an issue of multiple comparisons. Stratification on these variables was part of the original study design, and gender stratification was supported by published research.[50,51] No other stratification was performed during the analysis. Stratification reduced the sample size of each subgroup in the regression model and is the likely reason for the large confidence intervals seen in Table 3. This group of older adult volunteers may not be representative of all older adults. Participants were enrolled in the same health maintenance organization and might vary from the general population with respect to income and education. The use of self-reported physical activity instead of objectively measured physical activity introduced the potential for social desirability bias in the measure. In addition, the measure of self-reported activity queried participants for the number of sessions at least 15 minutes long; participants did not record sessions less than 15 minutes in duration. This could underestimate the activity of participants living close to desirable destinations.

The walkability model used in our study was created and tested in an urban setting in the Pacific Northwest. It might not apply to rural communities or to urban communities in other regions, where different factors may influence walkability. The WBC model controlled for survey-based sociodemographic factors, neighborhood perception, and attitude toward the environment. However, objective measures of crime, safety, and social support that might influence the walkability of a neighborhood should be evaluated in future models to refine predictors of walking. Finally, although the study successfully geocoded 90% of all participants, 47% lived outside the defined spatial sample frame of the WBC walkability model. This reduction in sample size potentially reduced the power of the analysis.

## Conclusions

Despite these limitations, this study adds to the growing body of literature about walkable communities and health. Older people are at particular risk for functional decline. Habitats that encourage physical activity and help reduce unhealthy body weight may be beneficial. Older people, a rapidly growing part of the population, may seek communities that promote active living. The demand for this type of residential environment could influence developers and designers to create communities that promote walking and improve the health of their residents. Most important, application of findings such as these can help older people preserve their function, independence, and quality of life. ■

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## Contributors

E.M. Berke originated the study, supervised all aspects of its implementation, performed data analysis, and wrote the article. T.D. Koepsell assisted with the study design and analyses and contributed to the writing of the article. A.V. Moudon is the principal investigator of the Walkable and Bikable Communities Project, from which geographic data were drawn. She assisted with study design and contributed to the writing of the article. R.E. Hoskins assisted with the study concept and analysis. E.B. Larson is the principal investigator of the Adult Changes in Thought study, from which the population was drawn. He assisted with the study design and analyses and contributed to the writing of the article.

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## Human Participant Protection

This study was approved by the institutional review boards at the University of Washington and Group Health Cooperative.

## References

1. Mokdad AH, Bowman BA, Ford ES, Vinicor F, Marks JS, Koplan JP. The continuing epidemics of obesity and diabetes in the United States. *JAMA.* 2001; 286:1195–1200.

2. Haslam DW, James WP. Obesity. *Lancet.* 2005; 366:1197–1209.

3. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among U.S. adults, 1999–2000. *JAMA.* 2002;288:1723–1727.

4. Arterburn DE, Crane PK, Sullivan SD. The coming epidemic of obesity in elderly Americans. *J Am Geriatr Soc.* 2004;52:1907–1912.

5. Marchesini G, Melchionda N, Apolone G, et al. The metabolic syndrome in treatment-seeking obese persons. *Metabolism.* 2004;53:435–440.

6. Calle EE, Rodriguez C, Walker-Thurmond K, Thun MJ. Overweight, obesity, and mortality from cancer in a prospectively studied cohort of U.S. adults. *N Engl J Med.* 2003;348:1625–1638.

7. Johnston E, Johnson S, McLeod P, Johnston M. The relation of body mass index to depressive symptoms. *Can J Public Health.* 2004;95:179–183.

8. Geoghegan JM, Clark DI, Bainbridge LC, Smith C, Hubbard R. Risk factors in carpal tunnel syndrome. *J Hand Surg [Br].* 2004;29:315–320.

9. Mehrotra C, Naimi TS, Serdula M, Bolen J, Pearson K. Arthritis, body mass index, and professional advice to lose weight: implications for clinical medicine and public health. *Am J Prev Med.* 2004;27:16–21.

10. Powell A, Teichtahl AJ, Wluka AE, Cicuttini FM. Obesity: a preventable risk factor for large joint osteoarthritis which may act through biomechanical factors. *Br J Sports Med.* 2005;39:4–5.

11. *Physical Activity and Health: Report of the Surgeon General.* Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion; 1996.

12. Gill TM, Williams CS, Tinetti ME. Assessing risk for the onset of functional dependence among older adults: the role of physical performance. *J Am Geriatr Soc.* 1995;43:603–609.

13. Katz S, Branch LG, Branson MH, Papsidero JA, Beck JC, Greer DS. Active life expectancy. *N Engl J Med.* 1983;309:1218–1224.

14. Wang L, van Belle G, Kukull WB, Larson EB. Predictors of functional change: a longitudinal study of nondemented people aged 65 and older. *J Am Geriatr Soc.* 2002;50:1525–1534.

15. Larson EB, Wang L, Bowen JD, et al. Exercise is associated with reduced risk for incident dementia among persons 65 years of age and older. *Ann Intern Med.* 2006;144:73–81.

16. Centers for Disease Control and Prevention. Healthy places terminology—designing and building healthy places. Available at: http://www.cdc.gov/healthyplaces/terminology.htm. Accessed August 12, 2005.

17. Moudon AV, Lee C. Walking and bicycling: an evaluation of environmental audit instruments. *Am J Health Promot.* 2003;18:21–37.

18. Humpel N, Marshall AL, Leslie E, Bauman A, Owen N. Changes in neighborhood walking are related to changes in perceptions of environmental attributes. *Ann Behav Med.* 2004;27:60–67.

19. Sallis JF, Hovell MF, Hofstetter CR. Predictors of adoption and maintenance of vigorous physical activity in men and women. *Prev Med.* 1992;21:237–251.

20. Collia DV, Sharp J, Giesbrecht L. The 2001 National Household Travel Survey: a look into the travel patterns of older Americans. *J Safety Res.* 2003;34:461–470.

21. Lee C, Moudon AV. Environmental correlates of walking for transportation or recreation purposes. *J Phys Act Health.* 2006;3:S77–98.

22. Moudon AV, Lee C, Cheadle A, et al. Operational definitions of walkable neighborhood: theoretical and empirical insights. *J Phys Act Health.* 2006;3:S99–117.

23. Kukull WA, Higdon R, Bowen JD, et al. Dementia and Alzheimer disease incidence: a prospective cohort study. *Arch Neurol.* 2002;59:1737–1746.

24. Teng EL, Hasegawa K, Homma A, et al. The Cognitive Abilities Screening Instrument (CASI): a practical test for cross-cultural epidemiological studies of dementia. *Int Psychogeriatr.* 1994;6:45–58; discussion 62.

25. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. *Appl Psychol Meas.* 1977;1:385–401.

26. Haringsma R, Engels GI, Beekman AT, Spinhoven P. The criterion validity of the Center for Epidemiological Studies Depression Scale (CES-D) in a sample of self-referred elders with depressive symptomatology. *Int J Geriatr Psychiatry.* 2004;19:558–563.

27. Fishman PA, Goodman MJ, Hornbrook MC, Meenan RT, Bachman DJ, O'Keeffe Rosetti MC. Risk adjustment using automated ambulatory pharmacy data: the RxRisk model. *Med Care.* 2003;41:84–99.

28. Lee C, Moudon AV. Physical activity and environment research in the health field: implications for urban and transportation planning practice and research. *J Plann Lit.* 2004;19:147–181.

29. King County GIS Center spatial data catalog. Available at: http://www.metrokc.gov/gis/sdc/index.htm. Accessed March 1, 2005.

30. Lee C, Moudon AV, Courbois JY Built environment and behavior: spatial sampling using parcel data. *Ann Epidemiol.* 2006;12:387–394.

31. Brownson RC, Baker EA, Housemann RA, Brennan LK, Bacak SJ. Environmental and policy determinants of physical activity in the United States. *Am J Public Health.* 2001;91:1995–2003.

32. Centers for Disease Control and Prevention. Physical activity for everyone: recommendations: are there special recommendations for older adults? Available at: http://www.cdc.gov/nccdphp/dnpa/physical/recommendations/older_adults.htm. Accessed April 15, 2005.

33. Moudon AV, Lee C, Cheadle A, et al. Attributes of environments supporting walking. *Am J Health Promot.* In Press.

34. Lee C, Moudon AV The 3D+R: quantifying land use and urban form correlates of walking. *Transportation Res Part D: Transport and Environment.* 2006;11:204–215.

35. Lim K, Taylor L. Factors associated with physical activity among older people–a population-based study. *Prev Med.* 2005;40:33–40.

36. Saelens BE, Sallis JF, Black JB, Chen D. Neighborhood-based differences in physical activity: an environment scale evaluation. *Am J Public Health.* 2003;93:1552–1558.

37. Lopez-Zetina J, Lee H, Friis R. The link between obesity and the built environment. evidence from an ecological analysis of obesity and vehicle miles of travel in California. *Health Place.* 2006;12:656–664.

38. Frank LD, Andresen MA, Schmid TL. Obesity relationships with community design, physical activity, and time spent in cars. *Am J Prev Med.* 2004;27:87–96.

39. Ewing R, Schmid T, Killingsworth R, Zlot A, Raudenbush S. Relationship between urban sprawl and physical activity, obesity, and morbidity. *Am J Health Promot.* 2003;18:47–57.

40. Giles-Corti B, Macintyre S, Clarkson JP, Pikora T, Donovan RJ. Environmental and lifestyle factors associated with overweight and obesity in Perth, Australia. *Am J Health Promot.* 2003;18:93–102.

41. Rutt CD, Coleman KJ. Examining the relationships among built environment, physical activity, and body mass index in El Paso, TX. *Prev Med.* 2005;40:831–841.

42. Frank LD, Schmid TL, Sallis JF, Chapman J, Saelens BE. Linking objectively measured physical activity with objectively measured urban form: findings from SMARTRAQ. *Am J Prev Med.* 2005;28:117–125.

43. Handy SL, Boarnet MG, Ewing R, Killingsworth RE. How the built environment affects physical activity: views from urban planning. *Am J Prev Med.* 2002;23:64–73.

44. Li F, Fisher KJ, Brownson RC, Bosworth M. Multilevel modelling of built environment characteristics related to neighbourhood walking activity in older adults. *J Epidemiol Community Health.* 2005;59:558–564.

45. King WC, Belle SH, Brach JS, Simkin-Silverman LR, Soska T, Kriska AM. Objective measures of neighborhood environment and physical activity in older women. *Am J Prev Med.* 2005;28:461–469.

46. Patterson PK, Chapman NJ. Urban form and older residents' service use, walking, driving, quality of life, and neighborhood satisfaction. *Am J Health Promot.* 2004;19:45–52.

47. Leyden KM. Social capital and the built environment: the importance of walkable neighborhoods. *Am J Public Health.* 2003;93:1546–1551.

48. Koepsell T, McCloskey L, Wolf M, et al. Crosswalk markings and the risk of pedestrian-motor vehicle collisions in older pedestrians. *JAMA.* 2002;288:2136–2143.

49. Miller ME, Rejeski WJ, Reboussin BA, Ten Have TR, Ettinger WH. Physical activity, functional limitations, and disability in older adults. *J Am Geriatr Soc.* 2000;48:1264–1272.

50. Troped PJ, Saunders RP, Pate RR, Reininger B, Ureda JR, Thompson SJ. Associations between self-reported and objective physical environmental factors and use of a community rail-trail. *Prev Med.* 2001;32:191–200.

51. Yancey AK, Wold CM, McCarthy WJ, et al. Physical inactivity and overweight among Los Angeles County adults. *Am J Prev Med.* 2004;27:146–152.